two-dimensional microelectromagnet wire matrix, as illustrated in FIGS. **3**(*a*)-(*d*), as well as one or more "ring traps," as illustrated in **FIG. 4**. These exemplary components are discussed in detail in PCT Application No. PCT/US02/36280, filed Nov. 5, 2002, entitled "System and Method for Capturing and Positioning Particles," International Publication No. WO 03/039753 A1, incorporated herein by reference.

[**0078**] **FIG. 3**(*a*) is a schematic illustration of a microelectromagnet wire matrix **200**A. According to one embodiment, the matrix comprises a top layer **202** and a bottom layer **204** of essentially straight conductors (e.g., gold or other metal wires or traces), wherein each layer is covered by an insulating layer **206** (e.g., polyimide) and the conductors of the respective layers are disposed in a transverse manner (e.g., the conductors of the top layer are perpendicular to the conductors of the bottom layer). In different implementations, this structure may be fabricated on a variety of substrates, one example of which includes a sapphire substrate. **FIG. 3**(*b*) illustrates a micrograph of such a fabricated wire matrix including electrical attachment leads, where an exemplary scale for the depicted fabricated device is indicated in the legend at the bottom right of the figure. **FIG. 3**(*c*) shows a magnified portion of the device shown in **FIG. 3**(*b*), which essentially corresponds to the conceptual depiction of **FIG. 3**(*a*). Finally, **FIG. 3**(*d*) is a micrograph of a cross-sectional view of the device, illustrating the vertical two-layer conductor/insulator structure.

[**0079**] In one embodiment based on the wire matrix shown in FIGS. **3**(*a*)-(*d*), each conductor in the wire matrix (or alternatively predetermined groups of conductors) may be connected to a controllable current source (discussed further below) so that all conductors (or groups of conductors) can have independent current flows. By independently modulating the magnitude of the currents in the conductors, various dynamic magnetic field patterns can be produced in proximity to (e.g., above) the wire matrix. For example, the currents can be controlled such that the wire matrix can create a single magnetic peak that is moving continuously, multiple peaks with each peak controlled independently, or varying magnetic fields to rotate or twist a target sample.

[**0080**] **FIG. 4** is a schematic illustration of a "ring trap"**208** which also may serve as a magnetic field-generating component in the hybrid system shown in **FIGS. 1 and 2**. The ring trap is a single essentially circular current-carrying conductor deposited on a substrate (e.g., a gold wire or trace deposited on a sapphire or other substrate) with an insulating layer on top. As current is made to flow through the circular conductor, a magnetic field is generated from the ring trap; in one example, in a circular ring having a diameter of approximately 5 micrometers (μm), a 30 milliampere (mA) current flowing through the conductor can generate a magnetic field of approximately 10 Gauss, corresponding to a magnetic force of approximately 10 pico Newtons (pN) (which is more than sufficient to attract and trap a bead-bound bacterium, for example). Such ring traps may be disposed in a variety of configurations in relation to a microfluidic system, including one-dimensional or two-dimensional arrays of ring traps.

[**0081**] Yet other examples of devices that may serve as magnetic field-generating components in the hybrid system shown in **FIGS. 1 and 2** include micro-scale magnets configured as coils, or "microcoils." Some examples of microcoils including ferromagnetic cores and fabricated using micromachining techniques are given in U.S. Pat. Nos. 6,355,491 and 6,716,642, as well as International Application Publication No. WO00/54882, each of which publications is incorporated herein by reference. Yet another example of magnetic field-generating components according to one embodiment of the present invention includes a CMOS microcoil array and associated control circuitry. Further details of such a CMOS microcoil array are discussed below in Section II.

[**0082**] It should be appreciated that for virtually any hybrid system **100** according to the present disclosure based on a microelectronics portion configured to generate controllable spatially and/or temporally variable magnetic fields, a parallel implementation may be realized using configurations for generating controllable spatially and/or temporally variable electric fields, or a combination of variable magnetic fields and variable electric fields.

[**0083**] For example, in one embodiment, the field-generating components **200** of the hybrid system shown in **FIGS. 1 and 2** may include an array of microelectrodes, or "microposts," configured to generate controllable electric fields for manipulating objects of interest according to principles of dielectrophoresis. FIGS. **5**(*a*) and (*b*) illustrate an example of such a micropost array **210**; **FIG. 5**(*a*) illustrates a micrograph of a top view of such a fabricated micropost array including electrical attachment leads, where an exemplary scale for the depicted fabricated device of 15 micrometers (μm) is indicated in the legend in the left portion of the figure, and **FIG. 5**(*b*) illustrates a magnified perspective view of the exemplary array of **FIG. 5**(*a*), showing a two-dimensional arrangement of five columns and five rows of microposts.

[**0084**] As discussed above, dielectrophoresis occurs when an inhomogeneous electric field induces a dipole on a particle suspended in liquid. The subsequent force on the dipole pulls the particle to either a minimum or a maximum of the electric field. Almost any particle, without any special preparation, can be trapped or moved using dielectrophoresis when it is exposed to the proper local electric field. In this manner, according to one embodiment, one or more samples of interest suspended in liquid in the microfluidic system **300** may be manipulated via operation of the micropost array **210** to generate electric fields appropriate for this task.

[**0085**] More specifically, in one embodiment based on the micropost array **210** shown in FIGS. **5**(*a*) and (*b*), each micropost in the array (or alternatively predetermined groups of microposts) may be connected to a controllable voltage source (discussed further below) so that all microposts (or groups of microposts) can have independent voltage potentials across them. By independently modulating the magnitude of the voltages across the respective microposts, various electric field patterns can be produced in proximity to (e.g., above) the micropost array **210** to facilitate manipulation of one or more samples of interest contained in the microfluidic system. To provide a ground for the respective micropost potentials, one exemplary geometry includes fabricating a ground plane adjacent to and above the micropost array (e.g., on a bottom surface of a microfluidic chamber), such that substantially all generated electric field lines point in the same direction. Alternatively,